

Rice-growing and conservation of the Southern Bell Frog* *Litoria raniformis* in New South Wales, Australia

Graham H. Pyke and Glenn W. Muir

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ABSTRACT

The Southern Bell Frog *Litoria raniformis* has declined dramatically in distribution and abundance in New South Wales, where it is presently considered 'endangered'. However, cultivation of rice through irrigation has created suitable habitat for this species, thus enabling it to colonise some, but not all, rice-growing areas. One such area, the Coleambally Irrigation Area, presently contains a large proportion of the remaining known locations of the species in New South Wales. Within this area this frog is widespread and locally abundant, and it uses flooded rice fields for breeding, though there are other kinds of water bodies that may also be used for breeding. The seasonal flooding regime for the rice mirrors the breeding requirements for this frog species. However, through reduction in flooding of natural habitat areas, diversion of water to rice and other irrigation-based agriculture has probably also contributed to the decline of this frog species and reversal of this through 'environmental flows' along rivers could be to its benefit. Its conservation in New South Wales is therefore likely to depend on the nature and extent of rice-growing in this state.

Key words: *Litoria raniformis*, rice, conservation

Introduction

The Southern Bell Frog or Growling Grass Frog *Litoria raniformis* was once a common frog species whose range extended from the south-east corner of South Australia, through most of Victoria (except western desert and eastern alpine areas), King and Flinders Islands, Tasmania (except the south-west), and the south-west of New South Wales (NSW), extending northwards along the western slopes of the Great Dividing Range to about Bathurst (Tyler 1997; Ashworth 1998; White and Pyke 1999; Cogger 2000; Pyke 2002). In NSW and the Australian Capital Territory (ACT), the species was mainly distributed around the Murray and Murrumbidgee Rivers and the southern and central tablelands to an elevation of about 1300 m (Osborne *et al.* 1996; Ehmann and White 1997; White and Pyke 1999; Cogger 2000).

The species has declined in distribution and abundance and is now considered 'vulnerable' nationally, both in the Action Plan for Australian Frogs (Tyler 1997) and under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (Pyke 2002; Clemann and Gillespie 2007). The most pronounced declines have occurred in the northern part of its range (NSW and the ACT) (Mahony 1999; DEC 2005), where it is now listed as 'endangered' by the Threatened Species Conservation Act 1995. The species has also disappeared from large parts of its range in Victoria (DEC 2005) and Tasmania (Ashworth 1998), and has become scarce in south-east South Australia (Tyler 1997). It is listed as 'threatened' by the Victorian Flora and Fauna Guarantee Act 1988, 'endangered' in Victoria by DSE (2007), 'vulnerable' by the South Australian National Parks and Wildlife Act 1972 and 'vulnerable' by the Tasmanian Threatened Species Protection Act 1995.

Declines of *L. raniformis* were apparently most pronounced during the same period as similar declines for its closely-related congener, the Green and Golden Bell Frog *Litoria aurea*. Both species declined precipitously in the southern and central tablelands and western slopes of NSW during the 1980s, with *L. raniformis* having disappeared altogether and *L. aurea* known only from one recently-discovered population (Osborne 1990; Osborne 1992; Osborne *et al.* 1996; White and Pyke 1999; Wassens and Mullins 2001). In Tasmania and the nearby King and Flinders Islands, *L. raniformis* declined during the 1980s, and by 1990 was known from a small number of isolated populations (Ashworth 1998). Discussions of the nature and extent of declines in Victoria and South Australia have not been published.

The reasons for these declines are unclear, but habitat loss, fragmentation and degradation, altered flood regimes, predation by the introduced Plague Minnow *Gambusia holbrooki*, drought, pollution, salinisation and disease have all been suggested, and other factors may have been involved (Osborne *et al.* 1996; Ehmann and White 1997; Tyler 1997; Mahony 1999; Pyke 2002; DEC 2005).

Many of the recent records of *L. raniformis* in NSW suggest that the species has persisted in irrigated rice-growing areas. From 1990 until the present study, *L. raniformis* was recorded from about 30 sites, mostly along the Murrumbidgee and Murray Rivers, but also within areas in between these two rivers (Fig. 1) (Ayers 1995; Sadlier *et al.* 1996; Ehmann and White 1997; Mahony 1997; AMBS 2000; Pyke 2002). Of the 25 locations recorded between the beginning of 1990 and the middle of

*Referred to as the Growling Grass Frog in Victoria

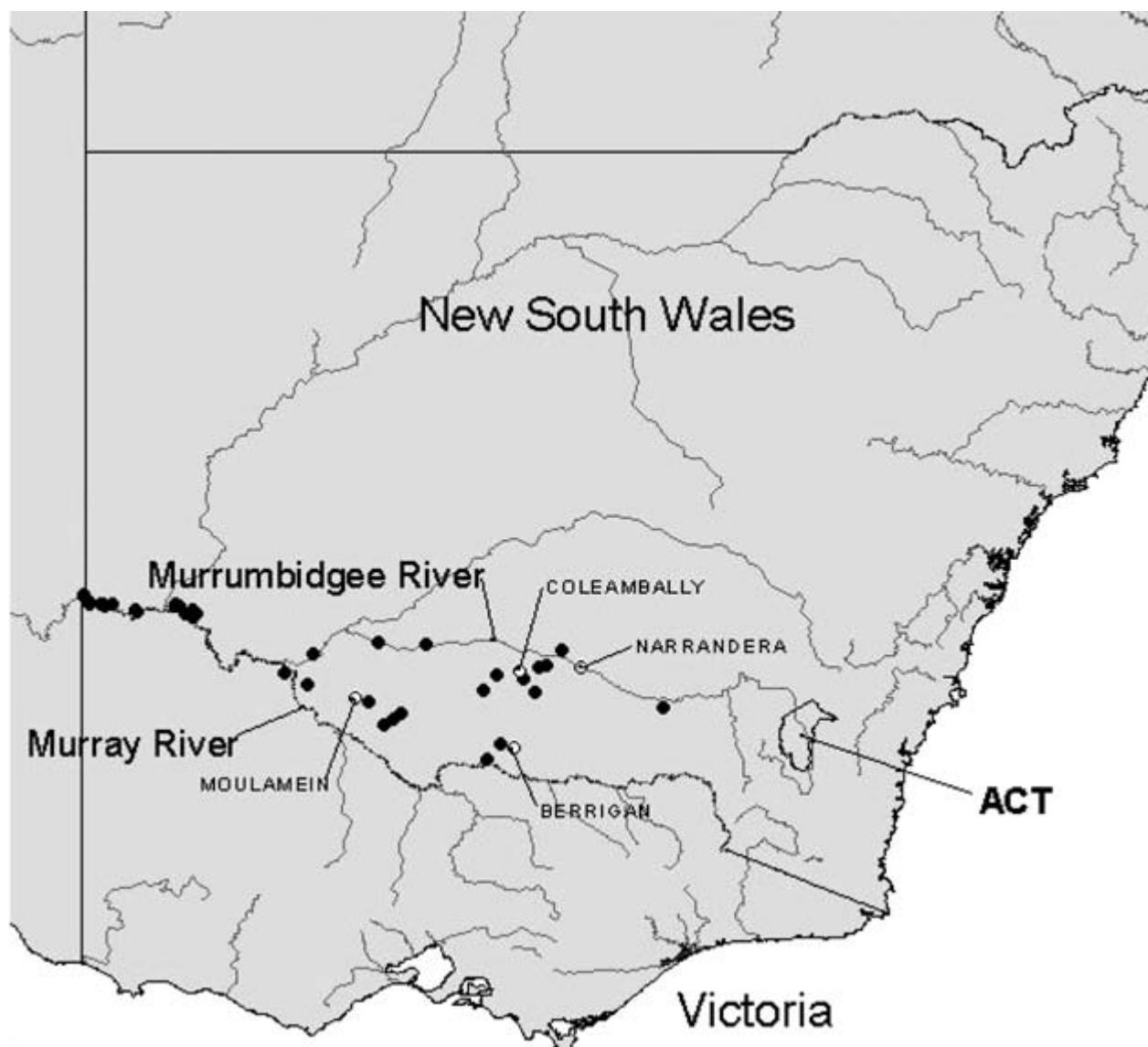


Figure 1. Records of *Litoria raniformis* in New South Wales from January 1990 to just before the present study.

1998, six were recorded within the Coleambally Irrigation Area (Fig. 1). The species was recorded at a further five locations within the Coleambally Irrigation Area during a biodiversity study carried out in the summer of 1998/99 (AMBS 2000). Furthermore, during targeted surveys that were carried out for the species throughout NSW between 1992 and 1995, 5 of 12 sites where the species was found had rice crops present within 50 m and at some of these locations the species was found in recently flooded rice fields (Ehmann and White 1997; A. White, Biosphere Environmental Consultants, pers. comm. 2001) (Fig. 1; one site near Berrigan; four sites near Moulamein; A. White pers. comm.).

The aims of the present study were to determine the broad distribution of *L. raniformis* across the Coleambally Irrigation Area, habitat attributes that were associated with its presence, and any patterns to its habitat use at the time. This was a 'snap-shot' view based on observations shortly after the end of the summer breeding season. At the beginning of this study there was no available information regarding the extent to which frog species use different kinds of habitat within the irrigation area.

Methods

Study area

The Coleambally Irrigation Area is located between the towns of Griffith and Jerilderie, approximately 25 km south of the Murrumbidgee River. It comprises about 80,000 ha of intensive irrigation, with more than 85% of the area dedicated to crops. During any one year about 20% of the area is sown with rice (A. Tiwari, Coleambally Irrigation Corporation, pers. comm.). Throughout the area, rice is rotated with grazing, other crops or a fallow period, and no land is used exclusively for rice.

The area contains abundant potential habitat for amphibian species capable of breeding in the irrigated fields or the network of water supply and drainage channels that service them. Typically, rice fields are dry during the period from about April to September; rice seeds are sown in about October and the crop is flooded from about October to March (Field 2000). During the rice-growing period there is also water in the supply and drainage channels. Roadside depressions that pond during rainfall events are also present and

in some locations are flooded through leakage from the rice bays or channels. There are also farm dams and a few relatively small depressions with remnant natural vegetation where rainwater may occasionally accumulate (AMBS 2000). Pasture areas are sometimes flooded to promote grass growth (Field 2000), and other crops (such as soybeans) require regular watering but not flooding.

This study was carried out throughout the Coleambally Irrigation Area between 25 February and 2 March 2001, whilst most rice bays were still flooded and water was present in many of the supply and drainage channels. Draining of rice bays prior to harvest of the rice occurs mostly during March (Wassens *et al.* 2008). Rainfall had occurred throughout the area in the days prior to the survey and runoff had collected in some of the roadside drains and other depressions that occur throughout the area. The study consisted of nocturnal road surveys and diurnal habitat assessments at sites where *L. raniformis* had been recorded. We made these habitat assessments at the five sites where the species had been recorded during the 1998/99 surveys, as well as at sites where we recorded it during the present study.

Road surveys were carried out each night between about 2030 and 0200 hours. A route was chosen for each night so that there was minimal overlap between different nights. Surveyed roads were spread across the area and most roads in the area were surveyed. The total distance surveyed in this way was about 253 km.

The road surveys involved driving at 30 km/h or less and scanning the road ahead for frogs. Frogs detected in this manner were identified, and the area within 50 m of any location where *L. raniformis* was detected was searched with spotlights for the presence of water bodies. Where water bodies were present, further searches for frogs were carried out. The numbers of adult (i.e., snout-vent-length > 5.5 cm) and immature (i.e., < 5.5 cm) *L. raniformis* (Pyke 2002; Wassens 2005; Hamer and Organ 2008) that were observed, along with the total person-hours and approximate transect distance spent surveying for this frog species, were recorded. These searches were generally between 10-30 minutes each, but lasted 1-2 hours in two cases where large numbers of *L. raniformis* were encountered. The numbers of any other frog species observed during this time were also recorded. The locations where any *L. raniformis* were detected were recorded. Locations where *L. raniformis* was detected that were separated by a distance of more than 1 km were defined as sites.

During the habitat assessments the following attributes were recorded: the numbers and kinds of water bodies within 50 m (i.e., supply channel, drainage channel, ditch, depression, dam), the nature and extent of terrestrial habitat within 50 m (i.e., grassland, pasture, woodland, rice, other crops; little or extensive), and the nature and extent of potential frog shelter (i.e., thick low vegetation, fallen timber). At water bodies at some of these sites, tadpoles and Plague Minnows were surveyed by visually scanning near the edges and then by sweeping

through the water with a small net (20 x 14 cm in area). Any frogs that were observed or heard calling were also recorded.

A possible association between where *L. raniformis* was found during the road surveys and the presence of a current rice crop adjacent to the road was considered by comparing the observed proportion of road survey sites with a current rice crop within 50 m with the proportion of our survey route that had a frontage of rice on either or both sides. The latter proportion was estimated to be 40% from aerial photographs taken earlier during February 2001, excluding 4.8 km of road that went through an area of forest, had no rice frontage and yielded no frogs. The difference between these two proportions was tested for significance with a Student t-test based on the Normal approximation to the binomial.

Results

We found *L. raniformis* at 32 widely scattered sites throughout the Coleambally Irrigation area (Fig. 2). We detected the species at three of the sites reported in AMBS (2000), at 27 sites during our road surveys (including one of the previous sites), and at three additional sites (Fig. 2). At eight of the 32 sites we observed both immature frogs and adults; at the other sites we observed only adults. Immature frogs accounted for about 7% of frogs observed (i.e., approximately 29 out of 403). We heard *L. raniformis* calling at two sites but did not record tadpoles of the species at any of the sites. We recorded *Limnodynastes tasmaniensis* at 12 of the sites and *Limnodynastes fletcheri* at 11 sites, including nine where both species were found. We found the Plague Minnow at six of the nine sites where we surveyed for fish.

There was much variation in the numbers of *L. raniformis* that we recorded at each site. At about half the sites (i.e., 18 of 32) we counted fewer than five individuals. However, at one site we counted 110 (100 adults; 10 immatures) in 1 person hour and, at another site, we counted 55 (54 adults; 1 immature) in 20 minutes of person time. These are high numbers compared with what is usually found during surveys of either this species or *L. aurea* (White and Pyke 1996; Ashworth 1998) (Pyke unpublished; A. White, pers. comm. 2001).

The sites where we found *L. raniformis* were very similar in a number of respects. As roads generally followed the same routes as the main water supply channels and water drainage channels, all but one of the road survey sites had either or both kinds of channel within 50 m. In all cases these contained water, and in some cases there were also ditches or depressions with water. There was also open water within 50 m of all the other sites where we found *L. raniformis*. In these cases the water bodies included smaller farm supply and farm drainage channels and a farm dam. Within 50 m of all the sites where we found the species there was an area of low grasses and herbs (either highly disturbed roadside vegetation or pasture or both). Two of the sites had small areas of woodland within 50 m, but other sites had no more than a few scattered trees within 50 m. All sites were essentially unshaded. At one site there was a small area of woodland further away. All of the

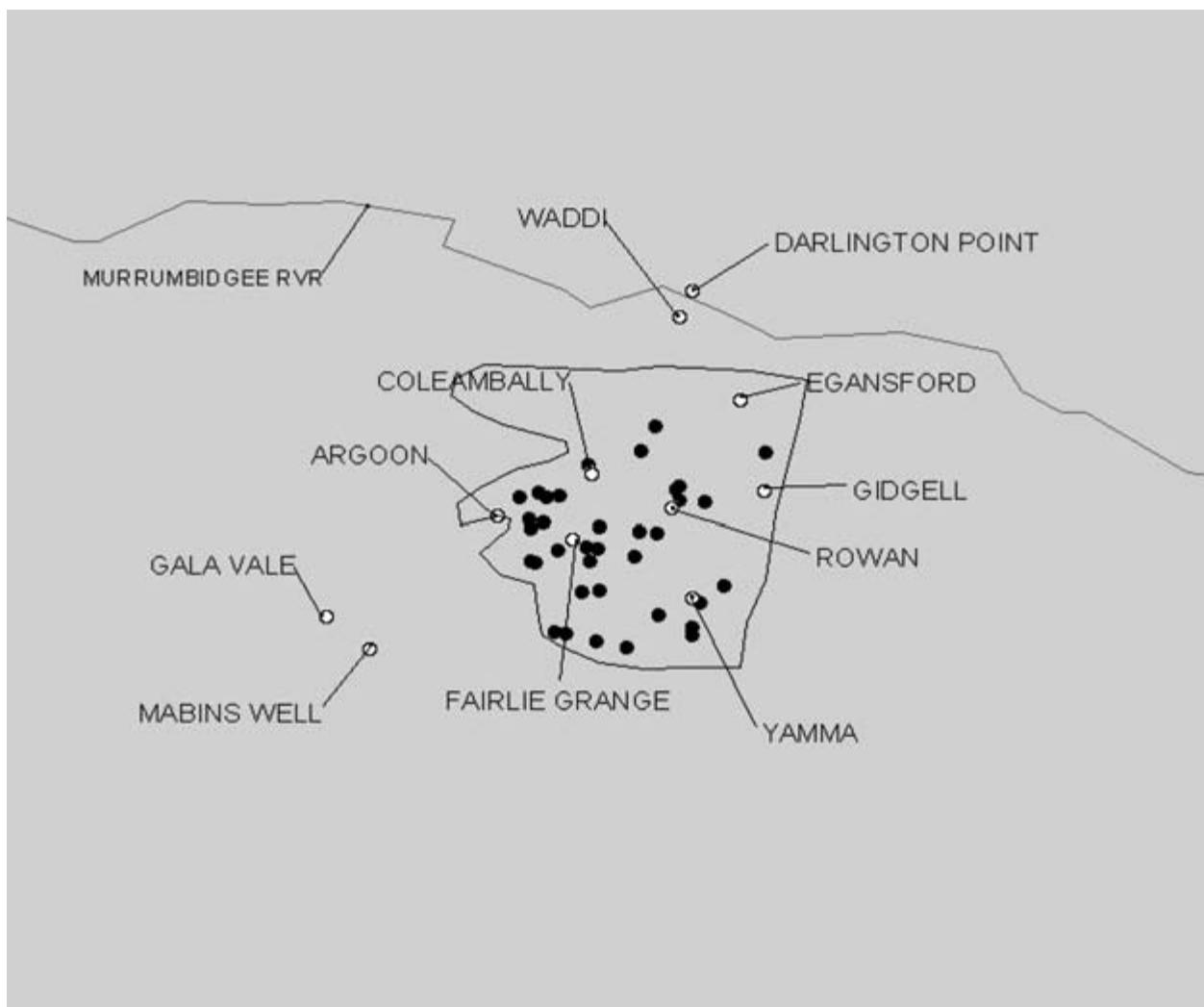


Figure 2. Records of *Litoria raniformis* from within the Coleambally Irrigation Area, including past records and those obtained during the present study.

sites were essentially human-made. The general landscape throughout the area was of a highly-modified agricultural nature with roads and water channels traversing an area dominated by current rice crops, fallow rice fields, pasture and occasionally some other crop.

At half of the sites where we recorded *L. raniformis* (i.e., 16/32) we found the species in or next to water (i.e., within about 2 m of water) and, though the nature of the water varied from site to site, it was mostly related to rice. In many cases where there was no adjacent water, there was none-the-less a nearby rice bay containing water (see below). We sometimes found the species associated with water-filled depressions that, although near rice crops, had no direct connections with the rice bays, their supply channels or their drainage channels (9 cases). In most (6) of these cases it appeared that the water resulted from leakage from rice-related water. We also found the species at the edges of rice bays where water was relatively open (5 cases), at a farm dam (1 case where also found at edge of rice), along a water supply channel (1 case) and along a water drainage channel (1 case).

There was a significant association between the sites where we found *L. raniformis* during our road surveys and the presence of a current rice crop within 50 m. There

was such a rice crop at 22 of the 27 sites (i.e., 81%); a significantly higher percentage than that observed for the extent to which the roads we surveyed had adjacent rice crops during the current season (i.e., 40%) ($P < 0.001$; Student *t*-test, based on Normal approximation to binomial).

Discussion

In the Coleambally Irrigation Area *Litoria raniformis* breeds mostly in rice bays or in adjacent depressions containing water that has leaked from rice bays, rather than in supply channels, drainage channels or other water bodies in the area. During our road-based surveys we tended to find this species at sites that had a current rice crop nearby, as expected if the frogs were breeding in the rice fields, rather than randomly along the roads, which would be expected if the frogs were breeding in either the supply or drainage channels as these channels run alongside most roads in the area. Water bodies other than rice field, supply channels and drainage channels are unlikely to be the major breeding sites for this species because we found it at many sites where there were no such other water bodies. Calling by males was most often recorded within rice bays or in water that had leaked from

a rice bay (Pyke, pers. obs.) and tadpoles were seldom recorded outside of these habitats (Pyke, pers. obs.; Wassens 2005). Both males and females of this species spend almost all of their time within and along the edge (i.e., within 3 m) of rice bays during the breeding season (Wassens 2005; Wassens *et al.* 2008). That we found frogs of this species at water bodies other than rice bays, and even at distances greater than 50 m from rice, is not unexpected because this species tends to move from rice bays to other permanent water bodies around February or March at the end of the breeding season (Wassens 2005; Wassens *et al.* 2007; Wassens *et al.* 2008).

The flooding regime for rice corresponds well to the natural breeding cycle of *L. raniformis* (Wassens 2005; Wassens *et al.* 2008). Under natural circumstances this species usually breeds in sites that are disturbed through flooding (Pyke 2002). Water-bodies at such sites may be ephemeral or may be 'permanent', in the sense that water is always present, with fluctuating water-levels (Pyke 2002). Rice-growing provides ephemeral ponds through an artificial flooding regime (Field 2000; Wassens 2005; Wassens *et al.* 2007). Under natural circumstances this species usually breeds during late spring or summer after flooding of wetlands through heavy rain, and about 2-3 months later most of the tadpoles metamorphose into frogs (Pyke 2002). Irrigated rice fields are flooded in spring and they remain flooded through the summer and into autumn (Field 2000). Hence rice fields provide an artificial flooding regime that mirrors natural regimes in many respects. In addition, our observation of immature frogs around the end of February is consistent with eggs having been laid in mid to late spring.

In addition to rice fields there are other water bodies in rice-growing areas that could sometimes provide breeding habitat for *L. raniformis*. Flooding regimes similar to those in rice fields may occur in depressions or drainage channels that are adjacent to rice fields and receive water through either leakage or overflow from the rice fields. Such flooding regimes may also occur in depressions that receive and accumulate storm water.

However, conditions may not be ideal for breeding by *L. raniformis* in rice fields or other water bodies that receive the same water. Rice fields are sprayed during the early part of the rice-growing season with various chemical insecticides and herbicides, and these may contaminate the water in these fields. Eggs and young tadpoles of *L. raniformis* may occur in this water at around this time. Plague Minnows invade much or all of the rice growing areas each season through the irrigation water (Wassens 2005). Further studies are needed to examine these potential impacts.

It is now apparent that *L. raniformis* presently has an association with rice-growing areas in NSW, especially the Coleambally Irrigation Area. We found the species to be widespread throughout the Coleambally Irrigation Area and relatively very abundant at some sites. This area now accounts for a large proportion of recent records for the species in NSW. Furthermore, many of the earlier records, and now most of the recent records for the species, have been closely associated with rice.

The ability of *L. raniformis* to successfully breed in rice fields and the destruction of natural breeding habitat for the species could explain this apparent association with rice. With agricultural development and associated modification to watercourses throughout the parts of NSW where this species originally occurred, little natural habitat remains (Ehmann and White 1997; Wassens 2005). With contemporaneous development of irrigated rice growing, suitable new habitat for the species may have been created. The development of irrigation-based agriculture in general, and rice-growing in particular, has probably also contributed to the decline of *L. raniformis* in its natural habitat through the diversion of water for irrigation and consequent reduction in flood waters received by natural wetland habitats (Wassens 2005).

However, it is not clear why *L. raniformis* has not been similarly reported in rice areas other than the Coleambally Irrigation Area or around Berrigan and Moulamein, because irrigated rice-growing currently occurs in several other areas within the original distribution of the species. For example, extensive irrigated rice-growing areas occur north of the Murrumbidgee River within the original range of this species (Field 2000; Pyke 2002), yet there are no recent records of the species from these areas (Fig. 1).

Conservation of *L. raniformis* in NSW is likely to depend to a large degree on the nature and extent of rice-growing in this state. Remaining populations outside of rice areas are under threat from further habitat loss and habitat modification, and some of these populations may have disappeared during the last 15 years (Ehmann and White 1997). Rice-growing areas may increasingly contain the remaining populations of this frog species. How the rice is grown may therefore determine the ultimate fate of this frog in NSW. On the other hand, if more water was allowed to flow down rivers such as the Murrumbidgee, thus creating more-natural flooding regimes of wetlands along these rivers, the suitability of these wetlands as natural habitat for *L. raniformis* might be improved, and this could also promote conservation of this species where it persists in these regions (Wassens 2005).

Knowledge of the biology of *L. raniformis* is limited and there is little available information upon which management or recovery of the species might be based (Pyke 2002; Wassens 2005). There is, in particular, little information regarding the patterns of habitat use and suitability for the species, and the factors that control distribution and abundance of this species, including the underlying causes for its decline (Pyke 2002). Such information is fundamental to protecting and managing this or any other species.

The Coleambally Irrigation Area offers opportunities both to develop biological knowledge with regard to *L. raniformis*, and to apply it to the local management of this species (Wassens 2005; Wassens *et al.* 2007). Because of the predominance of rice fields, this area provides a relatively simple and uniform environment in which to study frogs. Yet there is variation from one rice field to another in terms of a number of attributes including the underlying soil, duration and timing of flooding, application of chemicals, and abundance of predators. Sample size is also potentially large as there

are about 500 rice farms in the area, each with several rice fields. Hence it should be possible to determine the role and importance of these and other factors for *L. raniformis* through investigating the associations between the biology, distribution and abundance of this species and variation in these attributes (Wassens 2005). Since these attributes are largely controlled by the landowners of the area, both individually and collectively, it may also be possible to effect changes in the distribution

and abundance of this frog through changes in land management practices.

Studies of *L. raniformis* in its natural habitats should also contribute to the information necessary to promote its conservation (Wassens 2005). A knowledge, for example, of how this species is affected by the scale and timing of flooding events in areas of natural habitat could help to determine 'environmental flows' that would benefit this species (Wassens 2005).

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